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NASA Technology Days Overview Briefing

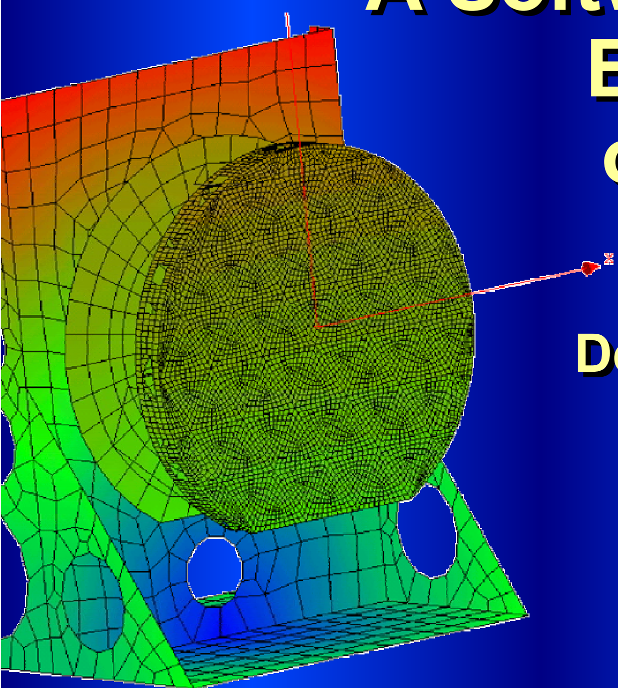
for

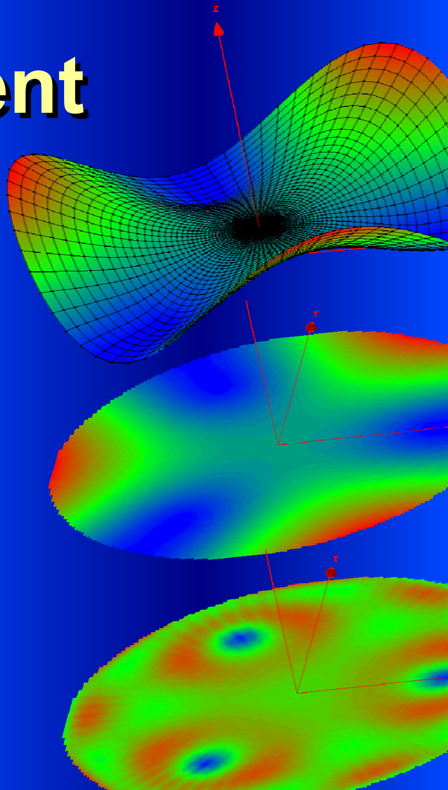
IODA

(Integrated Optical Design Analysis)

New Features and Improvements

A Software Tool for Concurrent Engineering Design of Optical Systems





24 May 2002

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Presented by Jim Moore

256-971-7020

Overview

Integrated Modeling Approach

Integrated Optical Design Analysis (IODA) Software Simplifies and Automates Data Sharing for Concurrent Design by a Diverse Team of Engineering Specialist

Topics

- Code Description and Model Interactions
- Summary of Features
- Actuator Influence Functions
- Figure Optimization Using Influence Functions
- Measured Data Import and Data Post Processing
- Dynamic Image Analysis
- Summary

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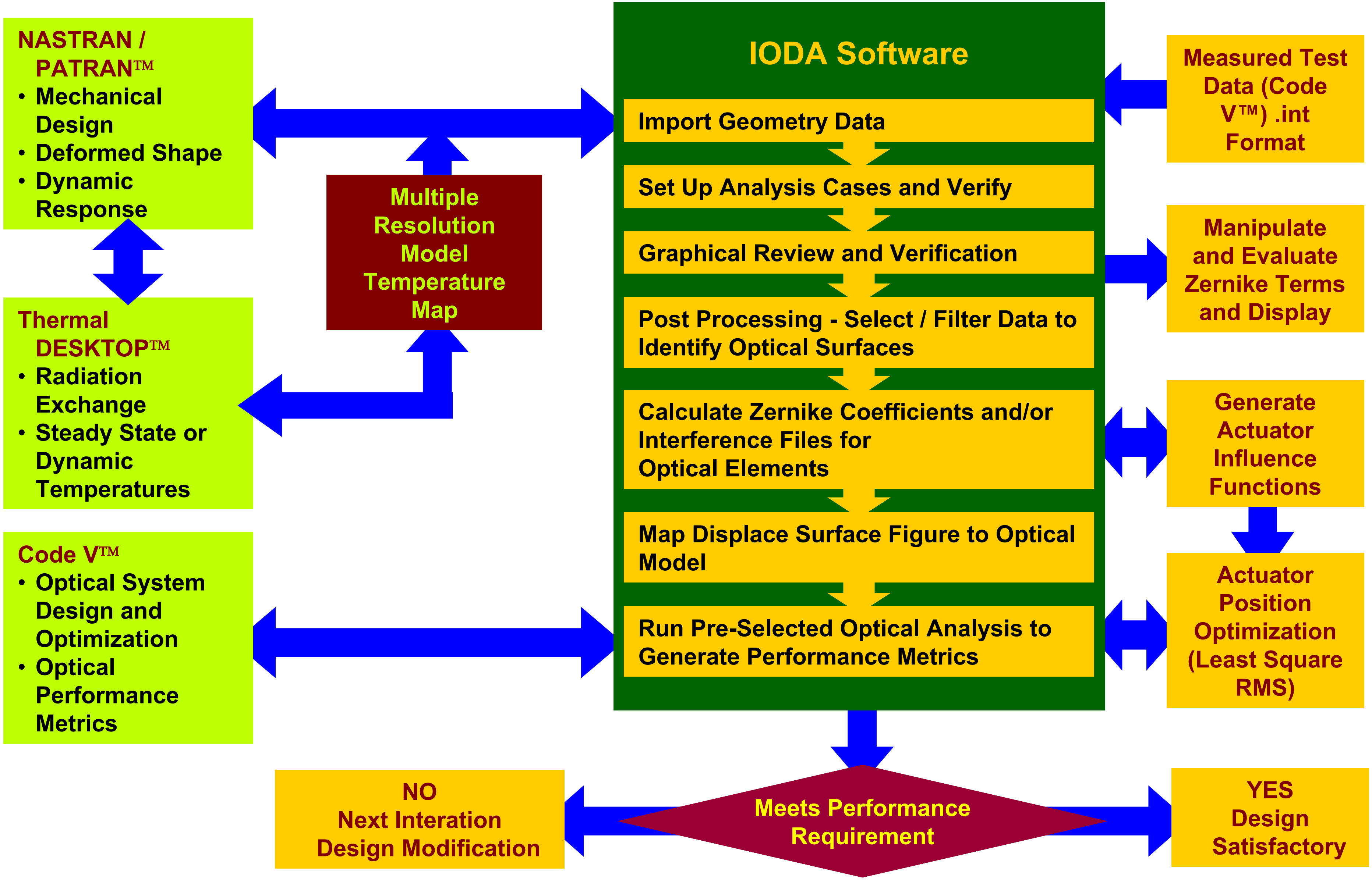
Schematic of Data Flow and Software Interactions



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Summary of IODA Features

- **Transfer Optical Surface Deflections from FEA to Code V™ for coupled Optomechanical Analysis**
  - **Select and Group Optical Surface Nodes**
  - **Map Optical Surface Deflections to a Uniform Grid as Required for Optical Model Definition**
  - **Generate Zernike Polynomials and/or Interferogram Files for Optical Model**
  - **Map Deformations into Optical Model Surfaces (Multiple Flexible Surfaces)**
- **Generate Parametric Analysis from Multiple Load Cases**
- **Automated Macros For Generating Most of the Optical Metrics versus Load Case**
- **Data Post Processing and Decomposition into Zernike Terms**
- ***ALGOR Interface Developed for Linear and Non-Linear FEA***
- ***Automated Generation of Influence Functions For Optical Surfaces***
- ***Least Squares Routine Developed to Solve for Actuator Positions to Minimize RMS Figure Error***
- ***Comparison of Measured Data to Modeled Data and Multiple Load Cases to Each Other***
- ***Dynamic Analysis Capability Added to Generate Wavefront and Image Analysis for Dynamic Loading***

Automated Generation of Actuator Influence Functions

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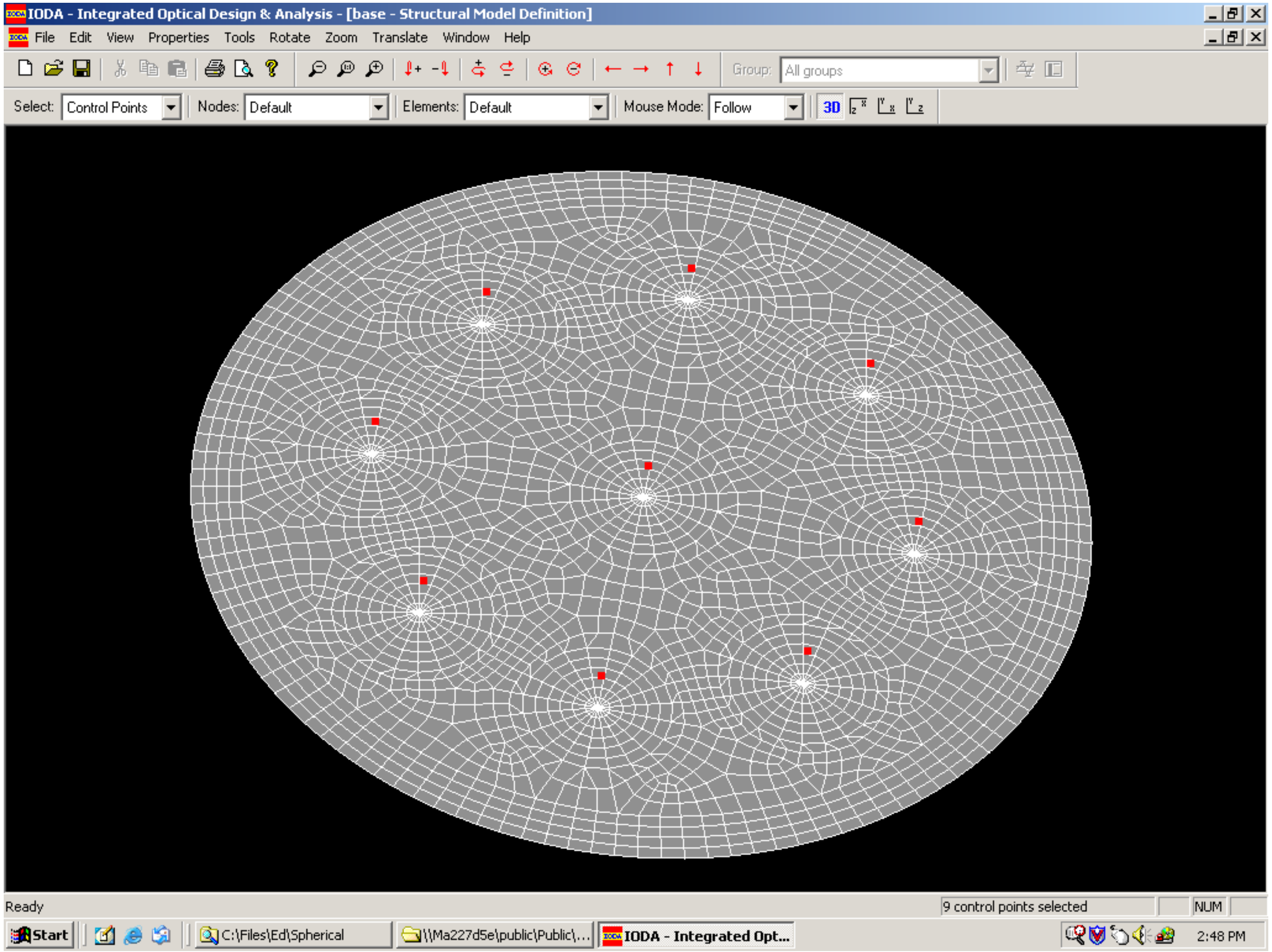

- Point-And-Click Interface Developed for Selecting Actuator Points and Creating Influence Functions
- Variable Stiffness Actuators Modeled Using SPCD in NASTRAN or Boundary Element in ALGOR
- Actuator Stroke in Optical Axis or User Defined Local Coordinate System
- Generates Influence Function for Each Actuator and Each Surface Node Included in IODA Optical Group

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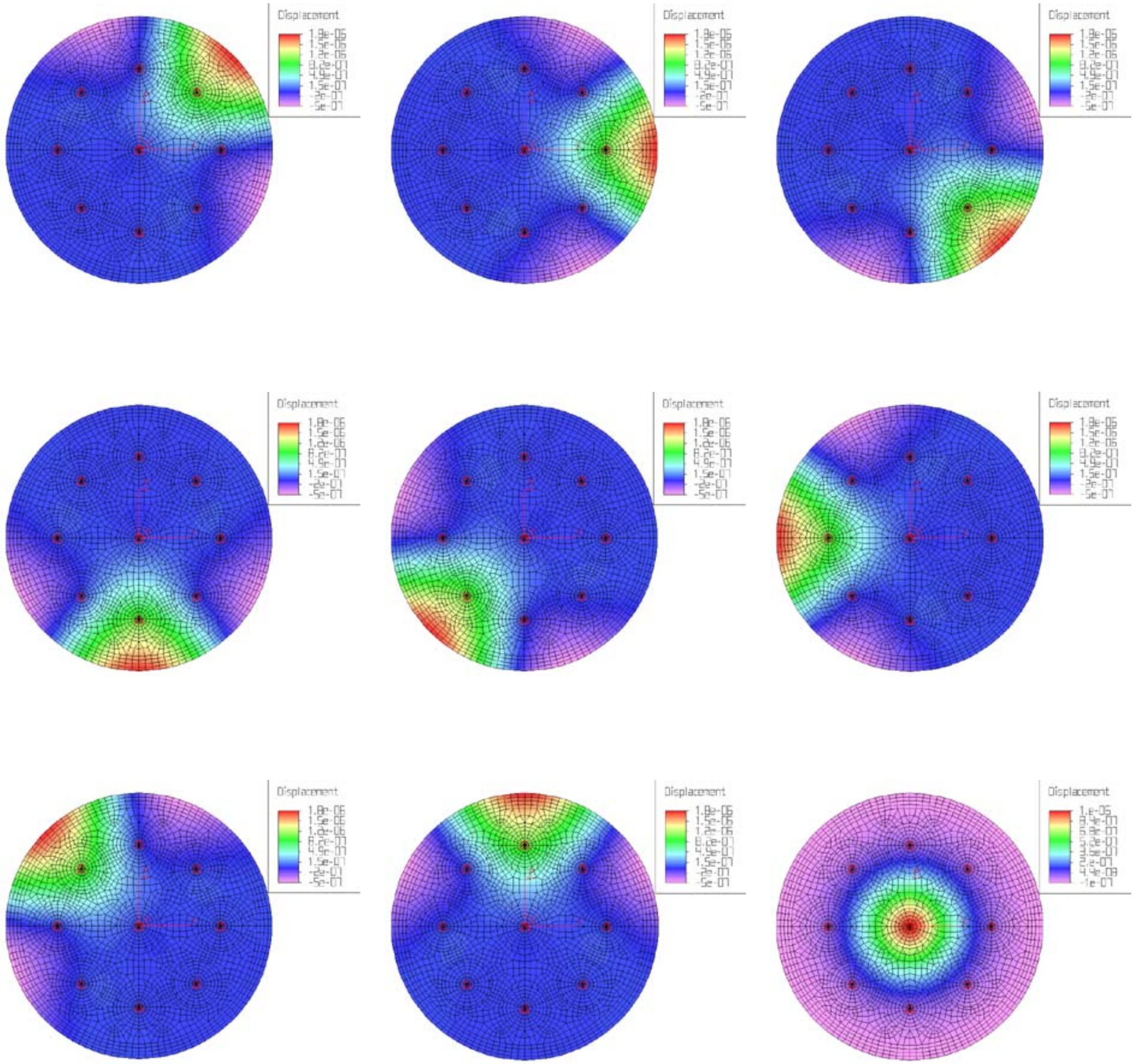
Influence Coefficients Generated for Spherical Mirror Model



- IODA Generates Influence Coefficients for Each Node Selected As a Control Point
- Generates and Stores I Matrix (Number of Control Points by Number of Surface Nodes) for Optimization Routine
- User Specified Actuator Stroke
- Influence Functions Can Be Generated for Any IODA Group

Least Squares Routine Developed for Figure Optimization Using Influence Functions

$\overline{e}$ = Inverse of Initial Error Vector

$[I]$ = Influence Matrix

$\overline{P}$ = Actuator Position Vector

Least Squares Solution for P Generated by Solving…

$$\overline{P} = [I^T I]^{-1} [I^T]\, e$$

δ_i = Nodal Deflection for Optical Surface Nodes

P = Actuator Positions That Satisfy

$$\sum_{i=1}^{n} (\delta_i - e_i)^2 = \text{Minimum}$$

Final Figure Calculated by Superimposing Initial Deflections with Deflections from Corrected Case

Note: Current Analysis Gives Each Node Equal Weighting; Weighting Function Options Under Development

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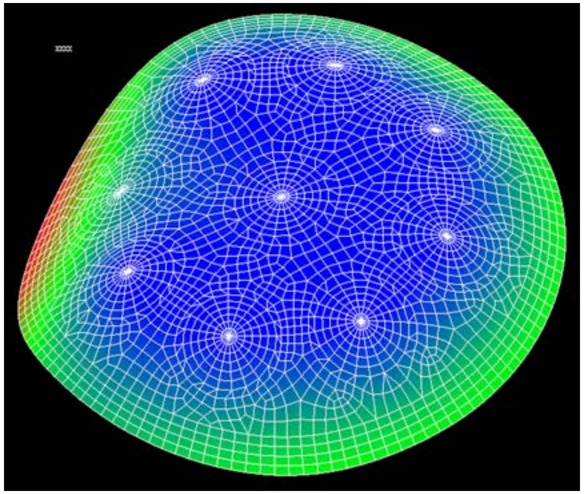
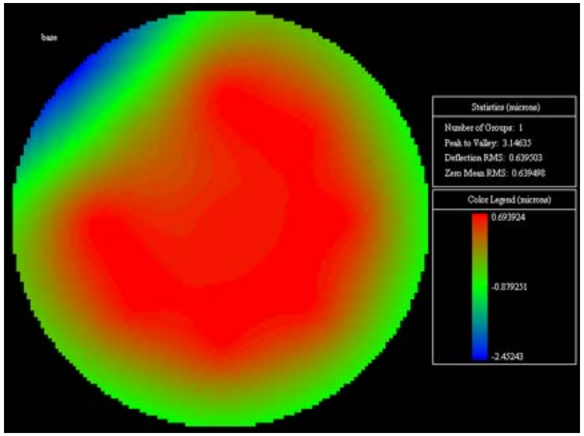
Figure Optimization Using IODA Influence Function and Least Squares Routine



Modeled Error Source (Gravity and Actuator Position Error)

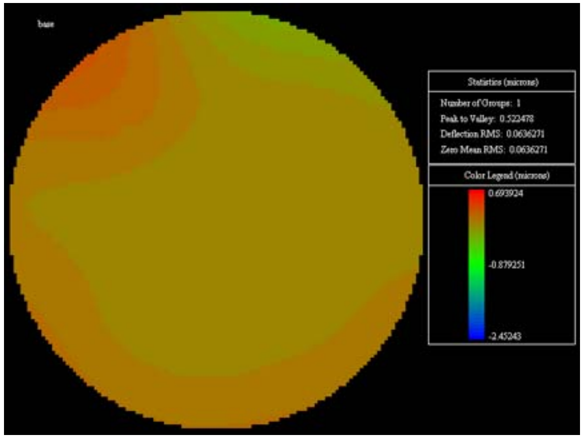
- 1-G Load in Optical Axis Direction
- 0.8 Micron Actuator Error on Actuator 7
- Deformation Scaling 50,000

RMS 0.639μ
P.V. 3.14μ



Uncorrected Figure

RMS 0.063μ
P.V. 0.522μ

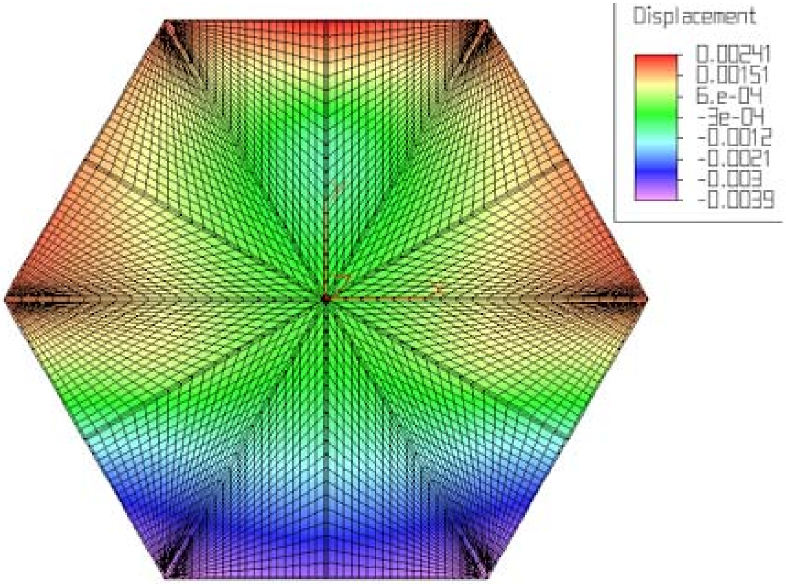


Corrected Figure

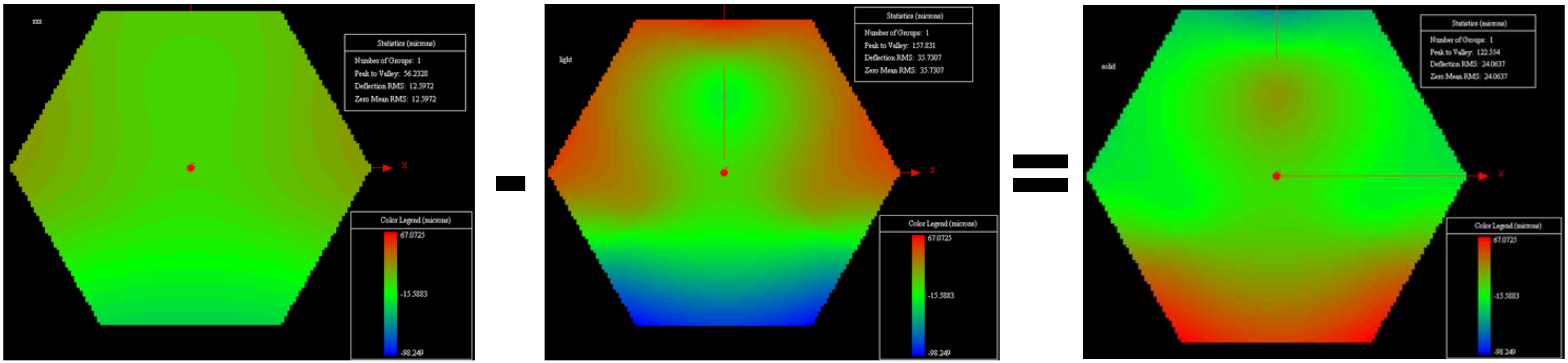
Optimized Actuator Positions

Number	Position (in x 10^{-5})
1	2.004
2	2.000
3	2.004
4	1.986
5	2.004
6	2.000
7	5.504
8	1.986
9	-2.793

Modeled Data Set Post Processing



- Evaluate Effects of Mirror Mount Changes, Material Substitutions or Design Changes
- Characterize the Nature of Changes Using Zernike Polynomial Fit Tools
- Supports Model to Model Comparison and Model to Measured Data Comparison



Measured Data Import and Post Processing Features

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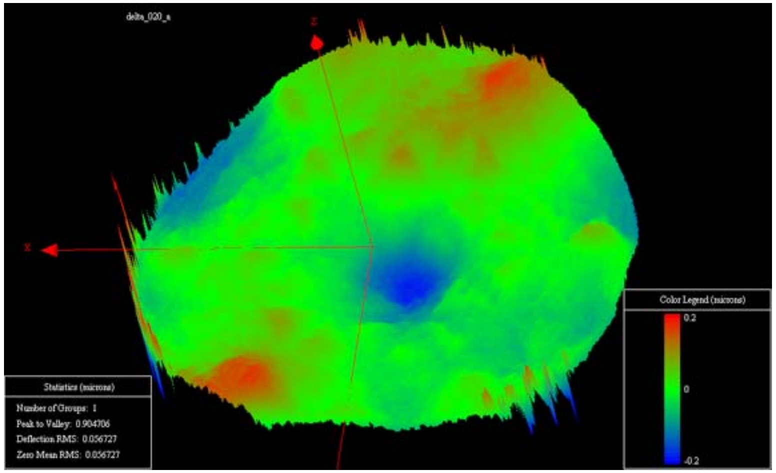
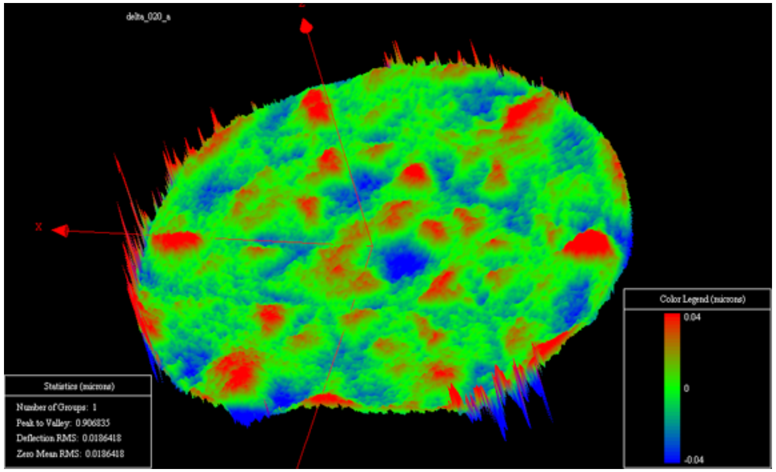
- Import Capability for Code V™ Compatible .int File From Measured Data (Uniform Grid or Zernike Formats)
- Data Can Be Fit and Manipulated Using IODA Zernike Routines
- Measured Data Can Be Subtracted From Model Results for Comparison
- Zernike Modeling of Differences Files
- Averaging of Multiple Data Sets



Example Data Input From XRCF Test



Imported Data File With 43 Wavescope Zernike Coefficients Removed

Dynamic Image and Wavefront Analysis

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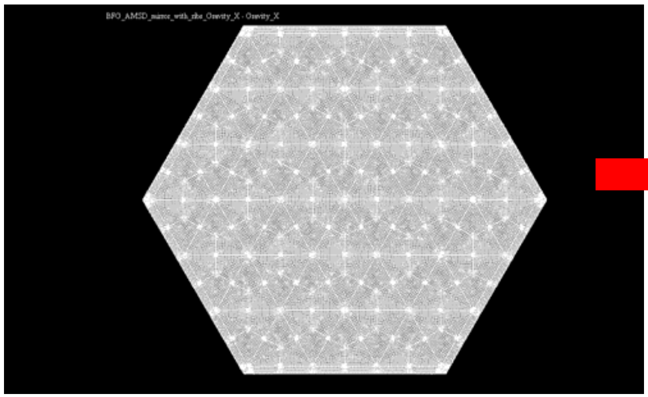
NASTRAN Model
- **Direct Transient Response (SOL 109)**
- **Model Transient Response (SOL 112)**

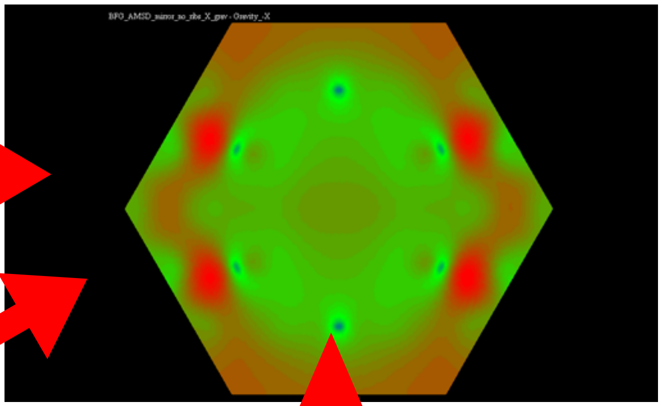
Displacement Output at User Specified Intervals

IODA Model Extracts Surface Deflections, Creates Code V .int Files, and Dynamically Updates Optical Model



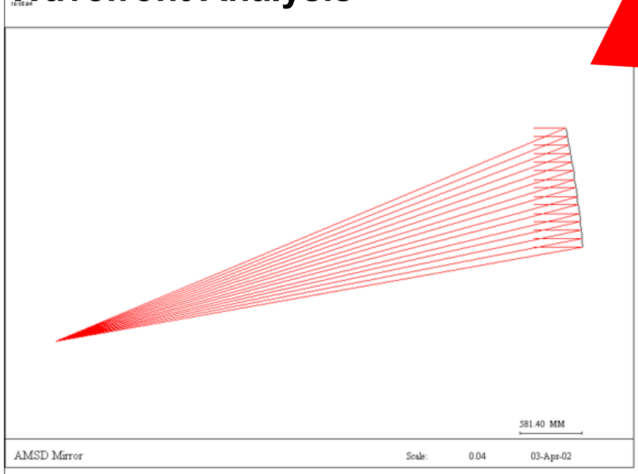
Geometry

Deflections (Time = 0 - Max)

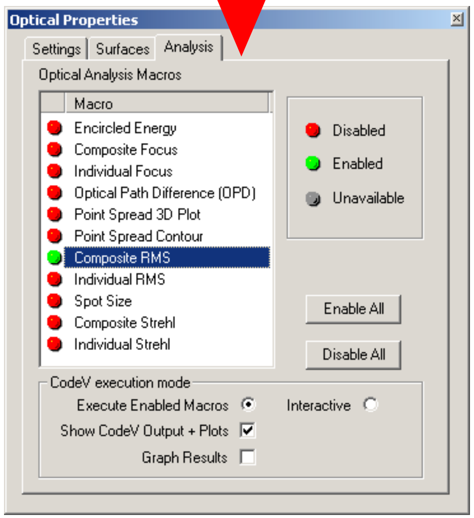


.int Files

Code V Model Raytrace and Wavefront Analysis



Raytraces (One Iteration per Time Step)



Output of Time Dependent Optical Results

Image Analysis Including System Dynamic Response

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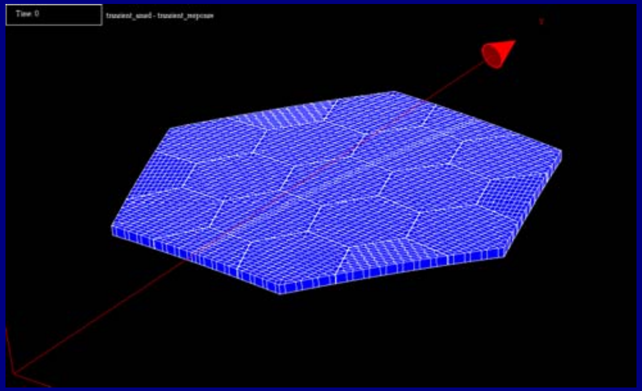
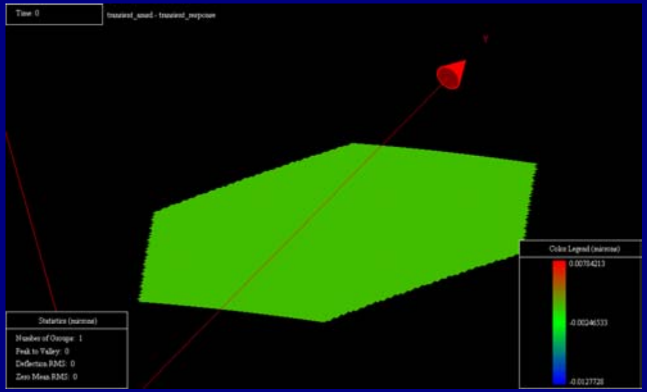
NASTRAN Dynamic Response Analysis

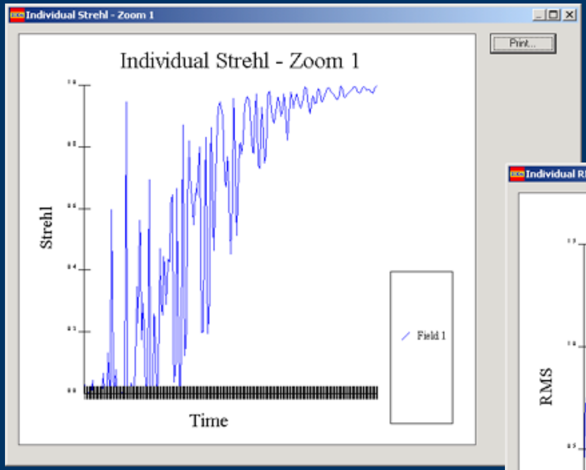


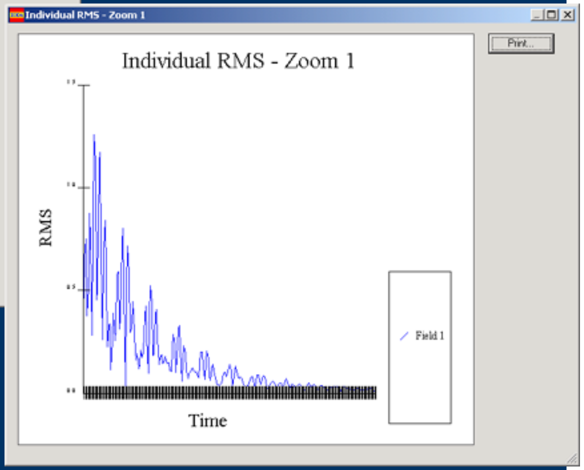
Nodal Displacement



IODA Generated Uniform Grid File

- IODA Processes Data From Dynamic Finite Element Analysis at Frequency of FEA Output
- Each IODA Optical Group's Time Dependent Displacements Are Mapped to Code V™ Sequence File
- Code V™ Macro List Is Supported to Generate Time Dependent Performance Metrics





Summary

- IODA Provides a User Friendly Graphical Interface Between Thermomechanical and Optical Analysis Tools
- Eliminates Many Potential Error Sources and Reduces Time Required for Integrated Modeling
- New Features Being Developed to Support AMSD Testing at MSFC
    - Actuator Influence Functions
    - Figure Optimization
    - Direct Import of Measured Optical Data
    - Dynamic Analysis Capability
- Demonstration Copies Available